Heeramun, R., Magnusson, C., Gumpert, C., Granath, S., Lundberg, M., Dalman, C., & Rai, D. (2017). Autism and convictions for violent crimes: population-based cohort study in Sweden. *Journal of the American Academy of Child and Adolescent Psychiatry*, *56*(6), 491-497.e2. https://doi.org/10.1016/j.jaac.2017.03.011

Autism and convictions for violent crimes: population-based cohort study in Sweden

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Acknowledgements: This work was not supported by any specific grant. The record linkages were supported by a grant by the Swedish Research Council (DNR 523-2010-1052). No funder had any role in the study design, data collection, and interpretation of results or reporting of this study. Michael Lundberg was the statistical expert in this paper.

Keywords: Autism; Crime; Offending; Outcomes; Epidemiology

ABSTRACT

Objective: Recent systematic reviews have highlighted that the relationship between autism and violent offending is still unclear, but some cases have received extensive media scrutiny. We investigated whether autism is associated with convictions for violent crimes, and studied the associated risk and protective factors.

Method: We analyzed data from the Stockholm Youth Cohort, a total population based record-linkage cohort in Stockholm County comprising 295,734 individuals followed-up between 15 through up to 27 years of age. Of these, 5,739 individuals had a recorded autism diagnosis. The main outcome measure was a conviction for violent crimes identified using the Swedish National Crime Register.

Results: Individuals with autism, particularly those without intellectual disability initially appeared to have a higher risk of violent offending (adjusted relative risk 1.39, 95% confidence interval 1.23-1.58). However, these associations markedly attenuated after co-occurring attention deficit hyperactivity disorder (ADHD) or conduct disorder were taken into account (0.85, 0.75-0.97). Among individuals with autism, male sex and psychiatric conditions were the strongest predictors of violent criminality, along with parental criminal and psychiatric history and socioeconomic characteristics. There was some evidence that a delayed diagnosis of autism was associated with a greater risk of violent crime. Better school performance and intellectual disability appeared to be protective.

Conclusions and relevance: An initially observed association between autism and violent crimes at a population level was explained by comorbidity with ADHD and conduct disorder. Better understanding and management of comorbid psychopathology in autism may potentially help preventative action against offending behaviors in people with autism.

INTRODUCTION

Autism spectrum disorders (henceforth referred to as autism) are developmental disorders with impairments in reciprocal social interaction and restricted repertoire of activities and interests.[1] Despite a major increase in the numbers of individuals being diagnosed with autism in recent years,[2 3] relatively little is known about what becomes of them later in life. Criminal offending is one important outcome of interest and some individual cases have received extensive media attention, perpetuating negative stereotypes about people with autism.[4] Although clinicians know that some people with autism display challenging behaviors and come in contact with the criminal justice system, whether autism itself increases the risk of violence is still unclear.

Such an association is plausible considering various features of autism such as impaired empathy, difficulties understanding emotional states of others, rigidity, and intolerance to change could potentially contribute to offending behaviours.[5 6] It has also been suggested that psychiatric co-morbidities in autism may contribute to the risk of offending.[7 8] On the other hand, people with autism can be very literal and pedantic in their adherence to the law, and a substantial proportion have intellectual disability which may result in reduced community access and greater supervision, and these factors may protect against offending behaviors[9].

Antisocial behaviors in autism were first reported by Asperger in his cohort of children with 'autistic psychopathy',[10] followed by several case studies documenting offending behaviors in people with autism,[11 12] particularly highlighting 'bizarre' and 'unusual' offending.[11] However, recent systematic reviews were inconclusive, reporting that much of the evidence on this topic to date was of 'poor' quality, and highlighted the need for robust research in the area.[5 6] They highlighted a wide and inconsistent range of estimates of criminality reported by previous studies which typically included small, selected samples without a comparison

group. A more recent Swedish population-based study found no evidence of an increased risk of violent criminality in 954 individuals with autism compared to controls.[13] However, it did not separate autistic individuals by presence of intellectual disability, which is important as this may influence the level of supervision or independent access to the community.

Apart from the inconsistent evidence on whether autism is associated with criminal behavior, there is very little information on risk and resilience factors in those with autism who do offend. A Swedish study of 422 inpatients with autism found that those convicted for violent crimes were more likely to be male, have a diagnosis of Asperger syndrome and had higher rates of psychiatric comorbidity and drug misuse compared to those who did not.[7] This, and other studies[8] implicating psychiatric morbidities have focused on adult conditions, but the role of childhood disorders such as attention deficit hyperactivity disorder (ADHD), known to be associated with autism and antisocial behaviors has not been examined. Furthermore, the suggestion that offending in autism may be correlated with a later age at diagnosis has yet to be substantiated.[14] Understanding the characteristics associated with offending in autism is crucial to help identify higher risk groups and the development of preventive strategies.[5]

We used data from a large population-based study in Sweden in order to address these omissions in the literature. The aims were: 1) to examine whether individuals with autism (with or without intellectual disability) were more likely to be at risk of violent offending than the general population ; and 2) to identify, within the population with autism, risk and protective factors associated with violent criminality.

METHODS

Study setting and design

The Stockholm Youth Cohort (SYC) comprises all children and young people 0-17 years, ever resident in Stockholm County between 2001 and 2011 (N=735,096).[3] Prospectively

recorded data for probands, and their first-degree relatives has been collected by record linkage to a range of national and regional healthcare, social, and administrative registers using personal identification numbers. Data were available until 31 December 2011 when the oldest cohort members were 27 years of age. For this study, we included individuals with a minimum age of 15 years, which is the age of criminal responsibility in Sweden. Participants were therefore followed up from 15 years through up to a maximum of 27 years of age. We excluded individuals whose records could not be linked to their parents, adopted children and those with missing information on potential confounders. The eligible sample thus comprised 295,734 individuals, of which 5,739 had an autism diagnosis (Figure 1).

Identification of autism

Individuals with autism in the SYC have been identified using a multi-source procedure described elsewhere.[15-17] Briefly, Sweden has universally accessible publicly funded services relevant to autism. Autism assessments are carried out by neuropediatric, child and adolescent mental health services, or specialist teams for adults. The diagnostic evaluations typically cover the person's social, medical, and developmental history, observation, and a structured assessment which includes cognitive testing. Diagnoses are recorded in the National Patient Register, the Stockholm County Child and Adolescent Mental Health Register and/or the Stockholm adult psychiatric outpatient register. We extracted diagnoses recorded in these registers (using codes from the International Classification of Diseases, ICD-9 (299.x) and ICD-10 (F84.x), respectively, or Diagnostic and Statistical Manual of Mental Disorders, fourth edition, (299.x)) and supplemented them by a record of care in specialist centers for autism with and without intellectual disability (ID), where an autism diagnosis and cognitive testing is a prerequisite. We have previously conducted two studies to validate autism diagnoses with and without intellectual disability recorded in the registers[15].

In the first, 170 of 177 (96%) case notes reviewed by two specialists supported a diagnosis of autism with respect to contemporary diagnostic criteria[15]. In the second, 23 of 27 (85%) twins recorded as having an ASD in the SYC who were a part of a national twins study of childhood neurodevelopmental disorders (CATSS) screened positive for ASD in that study, and only 1% of 2721 non-ASD twins in the SYC screened positive for ASD in CATSS[15].

Violent crimes

The National Crime Register contains data for all convictions in Sweden since 1973, including the personal identification number of the individual convicted, details of the crime, and the conviction date.[7 13] These details are recorded regardless of a custodial, non-custodial (including caution and fine) or mental health disposal. Swedish law does not have provisions of plea bargains or diversions prior to a trial and conviction process, regardless of the presence of disabilities or mental health problems. Sweden does not substantially differ from other European countries in the rates of violent crime and its resolution. It is estimated that 99.95% entries within the crime register are linked to a personal identification number.[7]

Crimes were categorized according to the Swedish Penal Code which contains provisions for most of the acts constituting a crime in Sweden. For this study, violent crimes included completed or attempted homicide or manslaughter, assaults (including gross bodily harm and other assaults) and unlawful threat with or without a weapon, sexual crimes (including rape, sexual coercion, sexual exploitation, indecent exposure or child molestation), robbery and arson, consistent with previous studies.[7]

Other characteristics

We used prospectively collected data on several personal and parental characteristics which could be considered as potential confounders. These included maternal age and paternal age

at birth of child, family income adjusted for year of ascertainment and family size in quintiles,[18] highest education of either parent (≤9 years, 10-12, ≥13 years), birth of parents or child outside of Sweden, parental history of violent crime convictions , and parental record of a psychiatric diagnosis. Co-occurring psychiatric disorders identified using the National patient register, the Stockholm child and adolescent mental health register, and the Stockholm adult psychiatric outpatient register included a registered diagnosis of ADHD (F90.x), conduct disorder including oppositional defiant disorder (F91.x), psychotic disorder (non-affective and affective psychoses F20.x-29.x, F31.x), personality disorder (F60.x) and drug and alcohol misuse (F10.x-19.x). Although all these individual diagnoses have not been validated, previous studies suggest a high validity of psychiatric diagnoses recorded in Swedish registers.[19 20] Data on the final composite school grade at the end of compulsory schooling at age 16 were obtained from the national school register[21] and dichotomized into top five versus bottom five deciles of school performance.

Statistical Analyses

Analyses were conducted using Stata 13. After descriptive analyses, we used modified poisson regression[22] to estimate the relative risks, with cluster robust 95% confidence intervals (accounting for clustering of children born to the same mother) of violent offending in people with autism compared to the population without autism. We conducted these analyses for autism spectrum disorder as a group, but also dichotomized by the presence or absence of intellectual disability, reflecting contemporary service models and prior studies highlighting important risk factors and outcomes between these groups.[16 17 23] We adjusted our initial model for sex (since autism and violent crime are more common in males), and age at end of follow-up (to account for chronological age as well as different follow-up times). In Model 2, we further adjusted for parental age and education, family income, migrant status,

history of violent crime and psychiatric diagnosis of each parent. In the final model, we adjusted for concurrent diagnoses of ADHD and conduct disorder (Model 3). To further assess the importance of comorbidity, we then stratified the population by the presence or absence of these conditions and repeated the analysis. Since other relevant, but later onset psychiatric disorders such as psychotic disorders, personality disorders or drug and alcohol misuse may be considered mediators or intermediate variables in the relationship, we did not adjust for them as this may introduce bias in the estimates[24]. However, we did study them separately, in analyses described below.

To study the characteristics associated with violent criminality in individuals with autism, we estimated the associations of individual (sex, school grades, age at autism diagnosis, ADHD, conduct disorder, psychotic disorder, personality disorder, drug and alcohol misuse, intellectual disability) and family level (maternal and paternal age, parental education and income, parental convictions for violent crimes and psychiatric disorders) characteristics in individuals with autism who were convicted of a violent crime versus those without convictions.

In sensitivity analyses, we repeated all the above analyses after removing individuals who received an autism diagnosis after having received a conviction for a violent crime.

Ethical approval

Ethical approval was obtained from the Research Ethics Committee at Karolinska Institutet, Stockholm [2013/1118-32].

RESULTS

The eligible population comprised 295,734 individuals, of which 5,739 had an autism diagnosis who had follow-up information available from at least 15 years to up to 27 years of

age. The characteristics of the study population are given in Table 1. By the end of follow-up, 250 (4.4%) cohort members with a diagnosis of autism, and 7,643 (2.6%) cohort members without autism had received at least one conviction for a violent crime.

Table 2 shows the relative risk of violent criminality in individuals with autism (and autism with or without intellectual disability) compared to the general population without autism. Individuals with autism appeared to be at a higher risk of convictions for violent criminality after adjustment for age, sex, and a range of parental characteristics (RR 1.39 95% CI 1.23 to 1.58), which appeared to be specifically raised in those without intellectual disability (1.63, 1.42 to 1.87). However, after adjusting for the presence of ADHD or conduct disorder, the risk estimates markedly attenuated (Table 2, model 3).

We repeated the analysis after stratifying the cohort by the presence or absence of ADHD or conduct disorder (Table 3). As compared to cohort members without a diagnosis of autism, ADHD or conduct disorder; those who had only ADHD or conduct disorder but no autism had the highest risk of violent criminality (RR 3.87 95%CI 3.62 to 4.13). There was little evidence for an increased risk of violent criminality in those with autism in the absence of ADHD or conduct disorder (1.10, 0.92 to 1.31) but autistic individuals who also had these co-occurring diagnoses had an increased risk of violent criminality (2.69, 2.28 to 3.17). A similar pattern of results was observed when the analyses were further stratified by intellectual disability but individuals who had autism with intellectual disability were less likely to be convicted (0.58, 0.38 to 0.88), and those who had autism without intellectual disability more likely to be convicted (1.37, 1.12 to 1.66) compared to `cohort members without any of these disorders (Table 3).

Table 4 shows the characteristics associated with violent criminality within individuals with autism. A range of parental and familial characteristics such as belonging to households with

lower incomes, migrant households, parental history of criminal convictions and maternal psychiatric disorders were associated with violent criminality in individuals with autism. Among individual characteristics, male gender and a diagnosis of ADHD, conduct disorder, psychotic disorders, personality and drug and alcohol misuse disorders were associated with violent crime. A later age at first recorded diagnosis of autism also appeared to be associated with higher risk of convictions (RR per year of delayed diagnosis 1.05 95%CI 1.03 to 1.08). On the other hand, intellectual disability and better than average school grades appeared to be protective.

In sensitivity analyses, we removed 71 people with autism out of the 250 who had been convicted for a violent crime but had their first recorded diagnosis of autism in the registers after the date of conviction. The results (see Tables S1,S 2 and S3, available online) were largely similar with the following exceptions: the main association between autism and violent crime was attenuated (see Table S1, available online); there was no evidence of an increased risk of violent crime in those who had autism without intellectual disability in the absence of ADHD or conduct disorder (see Table S2, available online); and there was no association between increasing age at first diagnosis of autism and violent crime convictions (see Table S3, available online).

DISCUSSION

In this large population-based study, a higher proportion of individuals with autism, particularly those without intellectual disability, had been convicted of a violent crime by the maximum age of 27 years than those without autism. However, co-occurring ADHD and conduct disorder largely explained this increased risk. These conditions along with other later onset psychiatric disorders and alcohol and drug misuse were the most important individual predictors of violent criminality in autism.

To our knowledge, this is the largest study on this topic to date. The total-population cohort design minimizes the possibility of selection and recall bias. Our multisource approach for case identification is likely to have minimized exposure misclassification compared with studies ascertaining autism solely from inpatient records,[7] or a single source.[13] Convictions were ascertained using the Swedish crime register which records all criminal convictions in Sweden. Importantly, these data offer an advantage for epidemiological investigations of psychiatric disorders as there are no plea bargains or diversions prior to a trial and conviction process and are therefore likely to be an accurate reflection of the cohort's resolved criminality. Violent offending is understood to peak between the ages of 15 to 20 years and then decreases substantially,[25] so our follow-up until age 27 years offers the advantage of capturing the peak incidence of violent crimes in the population. The extensive data available allowed for consideration of a number of important potential confounders. Specifically, we are not aware of studies accounting for the role of childhood ADHD or conduct disorder which are associated with autism, and are well known predictors of crime.[26] The ability to distinguish autism by the presence or absence of intellectual disability was important, considering individuals with greater levels of disabilities may have more supports in their environment, close monitoring and less independent access to the community reducing their chances to offend.

Several limitations in this study should be considered. Crimes are under-reported in society, and it is possible that criminal behavior, particularly violence or assaults against carers is tolerated to a greater extent and under-reported in individuals with developmental disabilities such as autism, particularly in the presence of intellectual disability.[27 28] This was reflected in our results and individuals who had autism with intellectual disability appeared to have a protective association with violent crime. However, the associations were similarly raised for

people with or without intellectual disability when ADHD or conduct disorders were also present. On the other hand, individuals with autism under trial may be more likely to receive a conviction due to being more suggestible, acquiescent or adherent to the truth.[29 30] These factors could lead to some differential outcome misclassification bias and could be an important limitation that is likely to affect any similar observational study. It was not possible to estimate risks for individual crimes due to small numbers, and larger studies would be required to address whether autism is associated with specific types of crimes at the population level. Finally, although this study is readily generalizable to the Swedish population, generalization to other populations should be made with caution.

Over a quarter of the individuals with autism in the cohort also had a diagnosis of ADHD or conduct disorder, and the co-occurrence of these disorders with autism appeared to strongly influence convictions for violent offending. Children diagnosed with ADHD or conduct disorders are known to be at an increased risk of antisocial behaviors and violent offending,[26 31] and this was also reflected in our results. Interestingly, our findings suggest that the additional presence of an autism diagnosis was associated with a reduced risk of convictions relative to having these conditions without autism. Our study mirrors recent findings suggesting that ADHD may be an important factor in the development of antisocial behaviors in children with neurodevelopmental problems.[31] Furthermore, there is some evidence from observational research that treatment of ADHD was associated with reduced risks of criminal offending.[32] This raises the potential for early recognition of higher risk groups within the autism population, and possible prevention of future criminal activity. This should be a topic of further research and discussion.

Many of the other characteristics associated with criminal convictions in people with autism, including socioeconomic factors, substance misuse and psychiatric morbidity mirrored

known risk factors for criminality in the general population.[33] The relationship between better academic achievement and lesser likelihood of crime is also well known.[33] It is important to highlight that despite their possible over-representation in people with autism,[23] psychiatric comorbidities in autism remain understudied. Service models for adults with autism, particularly in European countries are often focused on providing autism diagnoses rather than ongoing management or treatment of comorbidities.

An intriguing finding was that a later diagnosis of autism appeared to be related to an increased risk of criminal convictions. This finding has been reported previously,[14] but did not persist in analyses removing individuals who were registered with autism after having received a criminal conviction. It is therefore difficult to conclude whether an early diagnosis protects against criminal behaviors, or whether this association reflects bias related to other characteristics, such as greater severity (and thus greater supervision or reduced access to the community) or referral bias (a greater proportion of unidentified autism cases in the population being diagnosed following criminal convictions than in the general population). Regardless, it was notable that over a quarter of individuals with autism and criminal convictions had received a diagnosis only after they had already been convicted. Apart from other benefits of early diagnoses, whether it could play a role in the prevention of antisocial behaviors is a topic for future research.

In conclusion, the initial observed association between autism and convictions for violent crimes at a population level in this study was explained by comorbidity with ADHD and conduct disorder which substantially increased the risk. Better understanding and management of psychiatric comorbidity in autism may hold the potential for preventative action against antisocial behaviors and improved outcomes for people with autism.

Clinical guidance

- Over 28% of individuals with autism in this population based study also had a diagnosis of ADHD or conduct disorder and these comorbidities appeared to strongly influence convictions for violent crime.

- In the absence of these comorbidities, individuals with autism were no more likely to have convictions for violent offending than the general population.

- Early identification and management of mental health and neurodevelopmental comorbidity may have the potential to help reduce antisocial behaviors in individuals with autism.

References

1. Lai MC, Lombardo MV, Baron-Cohen S. Autism. *Lancet* 2014;383(9920):896-910. doi: S0140-6736(13)61539-1 [pii];10.1016/S0140-6736(13)61539-1 [doi]
2. Prevalence of autism spectrum disorder among children aged 8 years - autism and developmental disabilities monitoring network, 11 sites, United States, 2010. *MMWR Surveill Summ* 2014;63(2):1-21. doi: ss6302a1 [pii]
3. Idring S, Lundberg M, Sturm H, et al. Changes in prevalence of autism spectrum disorders in 2001-2011: findings from the Stockholm youth cohort. *J Autism Dev Disord* 2015;45(6):1766-73. doi: 10.1007/s10803-014-2336-y [doi]
4. Brewer N, Zoanetti J, Young RL. The influence of media suggestions about links between criminality and autism spectrum disorder. *Autism* 2017;21(1):117-21. doi: 10.1177/1362361316632097
5. Bjorkly S. Risk and dynamics of violence in Asperger's syndrome: A systematic review of the literature. *Aggression and Violent Behavior* 2009;14(5):306-12.
6. King C, Murphy GH. A systematic review of people with autism spectrum disorder and the criminal justice system. *J Autism Dev Disord* 2014;44(11):2717-33. doi: 10.1007/s10803-014-2046-5 [doi]
7. Langstrom N, Grann M, Ruchkin V, et al. Risk factors for violent offending in autism spectrum disorder: a national study of hospitalized individuals. *J Interpers Violence* 2009;24(8):1358-70. doi: 0886260508322195 [pii];10.1177/0886260508322195 [doi]
8. Newman SS, Ghaziuddin M. Violent crime in Asperger syndrome: the role of psychiatric comorbidity. *J Autism Dev Disord* 2008;38(10):1848-52. doi: 10.1007/s10803-008-0580-8 [doi]
9. Mouridsen SE, Rich B, Isager T, et al. Pervasive developmental disorders and criminal behaviour: a case control study. *Int J Offender Ther Comp Criminol* 2008;52(2):196-205. doi: 10.1177/0306624X07302056
10. Wing L. Asperger's syndrome: a clinical account. *Psychol Med* 1981;11(1):115-29.
11. Baron-Cohen S. An assessment of violence in a young man with Asperger's syndrome. *J Child Psychol Psychiatry* 1988;29(3):351-60.
12. Scragg P, Shah A. Prevalence of Asperger's syndrome in a secure hospital. *Br J Psychiatry* 1994;165(5):679-82.
13. Lundstrom S, Forsman M, Larsson H, et al. Childhood neurodevelopmental disorders and violent criminality: a sibling control study. *J Autism Dev Disord* 2014;44(11):2707-16. doi: 10.1007/s10803-013-1873-0 [doi]

14. Kawakami C, Ohnishi M, Sugiyama T, et al. The risk factors for criminal behaviour in high functioning autism spectrum disorders (HFASDs): A comparison of childhood adversities between individuals with HFASDs who exhibit criminal behaviour and those with HFASD and no criminal histories. *Research in Autism Spectrum Disorders* 2012;6:949-57.
15. Idring S, Rai D, Dal H, et al. Autism spectrum disorders in the Stockholm Youth Cohort: design, prevalence and validity. *PLoS One* 2012;7(7):e41280. doi: 10.1371/journal.pone.0041280 [doi];PONE-D-12-05428 [pii]
16. Magnusson C, Rai D, Goodman A, et al. Migration and autism spectrum disorder: population-based study. *Br J Psychiatry* 2012;201:109-15. doi: 10.1192/bjp.bp.111.095125
17. Rai D, Lee BK, Dalman C, et al. Parental depression, maternal antidepressant use during pregnancy, and risk of autism spectrum disorders: population based case-control study. *BMJ* 2013;346:f2059.
18. Rai D, Lewis G, Lundberg M, et al. Parental socioeconomic status and risk of offspring autism spectrum disorders in a Swedish population-based study. *J Am Acad Child Adolesc Psychiatry* 2012;51(5):467-76 e6. doi: 10.1016/j.jaac.2012.02.012
19. Dalman C, Broms J, Cullberg J, et al. Young cases of schizophrenia identified in a national inpatient register--are the diagnoses valid? *Soc Psychiatry Psychiatr Epidemiol* 2002;37(11):527-31. doi: 10.1007/s00127-002-0582-3 [doi]
20. Ludvigsson JF, Andersson E, Ekbom A, et al. External review and validation of the Swedish national inpatient register. *BMC Public Health* 2011;11:450. doi: 1471-2458-11-450 [pii];10.1186/1471-2458-11-450 [doi]
21. Shen H, Magnusson C, Rai D, et al. Associations of Parental Depression With Child School Performance at Age 16 Years in Sweden. *JAMA Psychiatry* 2016;73(3):239-46. doi: 2488039 [pii];10.1001/jamapsychiatry.2015.2917 [doi]
22. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004;159(7):702-06.
23. Selten JP, Lundberg M, Rai D, et al. Risks for nonaffective psychotic disorder and bipolar disorder in young people with autism spectrum disorder: a population-based study. *JAMA Psychiatry* 2015;72(5):483-89. doi: 2205837 [pii];10.1001/jamapsychiatry.2014.3059 [doi]
24. Schisterman EF, Cole SR, Platt RW. Overadjustment bias and unnecessary adjustment in epidemiologic studies. *Epidemiology* 2009;20(4):488-95. doi: 10.1097/EDE.0b013e3181a819a1
25. Moffitt TE. Adolescence-limited and life-course-persistent antisocial behavior: a developmental taxonomy. *Psychol Rev* 1993;100(4):674-701.
26. Satterfield JH, Faller KJ, Crinella FM, et al. A 30-year prospective follow-up study of hyperactive boys with conduct problems: adult criminality. *J Am Acad Child Adolesc Psychiatry* 2007;46(5):601-10. doi: 10.1097/chi.0b013e318033ff59 [doi];S0890-8567(09)61719-6 [pii]
27. Lyall I, Holland AJ, Collins S. Offending by adults with learning disabilities: identifying need in one health district. *Mental Handicap Research* 1995;8(2):99-109.
28. McNulty C, Kissi-Deborah R, Newsom-Davies I. Polive involvement with clients having intellectual disabilities: a pilot study in South London. *Mental Handicap Research* 1995;8(2):129-36.
29. Maras KL, Bowler DM. Brief Report: Suggestibility, compliance and psychological traits in autism spectrum disorder. *Research in Autism Spectrum Disorders* 2012;6(3):1168-75.

30. Woodbury-Smith M, Dein K. Autism spectrum disorder (ASD) and unlawful behaviour: where do we go from here? *J Autism Dev Disord* 2014;44(11):2734-41. doi: 10.1007/s10803-014-2216-5 [doi]
31. Noren SE, Molero Y, Lichtenstein P, et al. Childhood Symptoms of ADHD Overrule Comorbidity in Relation to Psychosocial Outcome at Age 15: A Longitudinal Study. *PLoS One* 2015;10(9):e0137475. doi: 10.1371/journal.pone.0137475 [doi];PONE-D-15-19725 [pii]
32. Lichtenstein P, Halldner L, Zetterqvist J, et al. Medication for attention deficit-hyperactivity disorder and criminality. *N Engl J Med* 2012;367(21):2006-14. doi: 10.1056/NEJMoa1203241 [doi]
33. Valois RF, MacDonald JM, Bretous L, et al. Risk factors and behaviors associated with adolescent violence and aggression. *Am J Health Behav* 2002;26(6):454-64.

Table 1 Characteristics of the eligible study population within the Stockholm Youth Cohort, by Autism spectrum disorder (ASD) with or without intellectual disability (ID)

	No ASD (n=289,995)	All ASD (n=5,739)	ASD without ID (n=4,131)	ASD with ID (n=1,608)
Characteristic				
Age (mean, sd)	21.2 (3.6)	20.3 (3.4)	20.2 (3.4)	20.4 (3.5)
Male	50.9	67.1	65.5	71.3
Paternal age (mean, sd)	31.9 (6.3)	32.2 (6.7)	31.8 (6.6)	33.0 (6.9)
Maternal age (mean, sd)	28.8 (5.2)	29.2 (5.7)	29.1 (5.5)	29.5 (5.7)
Lowest education parents	19.8	19.1	18.5	20.7
Lowest quintile of family income	21.9	18.6	16.5	24.2
Parent or child born outside Sweden	36.0	32.2	28.7	41.1
Maternal conviction for violent crime	1.2	1.8	1.8	1.9
Paternal conviction for violent crime	9.2	11.6	11.2	12.6
Mother has a psychiatric history	30.9	45.9	48.2	39.9
Father has a psychiatric history	18.6	26.8	27.7	24.3
ADHD or conduct disorder diagnosis	2.7	28.4	29.7	24.9
Diagnosis of ADHD	2.5	25.8	27.3	22.0
Conduct disorder	0.4	4.5	4.3	5.1
Psychotic disorder	0.7	5.2	5.9	3.4
Drug or alcohol misuse	5.6	8.9	10.9	3.7
Personality disorder	0.6	3.0	3.8	0.9

Follow-up				
Conviction for violent crime	2.6	4.4	4.9	3.1

Note: all numbers are column percentages except age variables which refer to mean (standard deviation)

Table 2. Relative risk (95% confidence intervals) of violent criminality in individuals with autism spectrum disorders (and autism with and without intellectual disability) in the Stockholm Youth Cohort

	RR (95% CI) Model 1	RR (95% CI) Model 2	RR (95% CI) Model 3
All autism spectrum disorders	1.55 (1.37-1.75)	1.39 (1.23-1.58)	0.85 (0.75-0.97)
Autism without intellectual disability	1.78 (1.55-2.04)	1.63 (1.42-1.87)	0.98 (0.85-1.13)
Autism with intellectual disability	1.02 (0.77-1.34)	0.86 (0.66-1.33)	0.56 (0.43-0.73)

Modified Poisson regression models with cluster robust standard errors (cluster=birth mother)

Model 1- adjusted for sex and age

Model 2- adjusted for age, sex, maternal and paternal age at birth, parental education at birth, household disposable income, migration status, maternal and paternal history of criminal conviction for violent offences, and maternal and paternal history of a psychiatric disorder

Model 3- model 2 further adjusted for the presence of co-morbidity with ADHD or conduct disorder in the proband

Table 3. Relative risk (95% confidence intervals) of violent criminality in individuals with autism, by the presence of ADHD or conduct disorder

Autism according to comorbidity			
All autism spectrum disorders	**ADHD/conduct disorder**	Model 1 RR (95% CI)	Model 2 RR (95% CI)
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.37 (5.05-5.72)	3.87 (3.62-4.13)
Present	Not present	1.18 (0.99-1.41)	1.10 (0.92-1.31)
Present	Present	3.16 (2.68-3.73)	2.69 (2.28-3.17)
Autism without intellectual disability	**ADHD/conduct disorder**		
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.37 (5.05-5.72)	3.87 (3.63-4.14)
Present	Not present	1.42 (1.17-1.73)	1.37 (1.12-1.66)
Present	Present	3.33 (2.76-4.01)	2.89 (2.40-3.49)
Autism with intellectual disability	**ADHD/conduct disorder**		
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.37 (5.05-5.72)	3.89 (3.64-4.15)
Present	Not present	0.65 (0.43-1.00)	0.58 (0.38-0.88)
Present	Present	2.67 (1.87-3.79)	2.14 (1.52-3.00)

Modified Poisson regression models with cluster robust standard errors (cluster=birth mother)

Model 1: adjusted for age and sex

Model 2: model 1 further adjusted for maternal and paternal age, parental education at birth, household disposable income, migration status, maternal and paternal conviction for violent crime, maternal and paternal history of a psychiatric disorder

Table 4. Relative risks of violent criminality among individuals with autism (n=5,739) in relation to family characteristics, psychiatric comorbidities, school grades and age at ASD diagnosis

	RR (95% CI)	Adjusted RR (95% CI)
Family characteristics		
Maternal age	0.93 (0.91-0.95)	0.97 (0.94-0.99)
Paternal age	0.95 (0.93-0.97)	0.99 (0.96-1.01)
Low education parents	1.56 (1.19-2.04)	0.97 (0.72-1.29)
Lowest income	1.74 (1.33-2.27)	1.43 (1.08-1.89)
Parent or child born abroad	1.56 (1.23-1.99)	1.45 (1.13-1.86)
Mother convicted of violent crime	2.70 (1.64-4.44)	1.61 (0.97-2.67)
Father convicted of violent crime	2.87 (2.20-3.74)	2.06 (1.55-2.74)
Mother has psychiatric history	1.63 (1.27-2.08)	1.32 (1.03-1.70)
Father has psychiatric history	1.28 (0.99-1.67)	1.01 (0.77-1.32)
Individual characteristics		
Male sex	2.00 (1.47-2.86)	1.88 (1.38-2.56)

ADHD or Conduct disorder	2.70 (2.13-3.43)	2.48 (1.95-3.15)
ADHD	2.39 (1.88-3.03)	2.19 (1.72-2.78)
Conduct disorder	4.19 (3.07-5.73)	3.50 (2.53-4.85)
Psychotic disorder	2.59 (1.87-3.60)	1.96 (1.41-2.72)
Drug and alcohol misuse	6.02 (4.68-7.76)	4.26 (3.23-5.61)
Personality disorder	2.73 (1.78-4.19)	2.32 (1.53-3.52)
Intellectual disability	0.60 (0.41-0.86)	0.52 (0.36-0.75)
Better than average school grades	0.44 (0.27-0.71)	0.58 (0.36-0.93)
Age of autism diagnosis (years)	1.08 (1.05-1.10)	1.05 (1.03-1.08)

Modified Poisson regression models, cluster robust standard errors (cluster=birth mother)

The adjusted model included all family characteristics, age and sex of proband and the presence of ADHD or conduct disorder.

Note: School grades available for 3398 individuals with ASD

Supplementary tables

Supplementary Table S1. Relative risk (95% confidence intervals) of violent criminality in individuals with autism spectrum disorder (ASD), with and without Intellectual disability (ID) in the Stockholm Youth Cohort. **The autism diagnosis was recorded before the criminal conviction.**

	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)
ASD	1.13 (0.98-1.31)	1.03 (0.89-1.20)	0.65 (0.56-0.75)
ASD without ID	1.24 (1.05-1.47)	1.17 (0.99-1.38)	0.71 (0.60-0.85)
ASD with ID	0.87 (0.65-1.18)	0.75 (0.56-1.01)	0.49 (0.37-0.66)

Modified Poisson regression models with cluster robust standard errors (cluster=birth mother)
Model 1- adjusted for sex and age
Model 2- adjusted for age, sex, maternal and paternal age at birth, parental education at birth, household disposable income, migration status, maternal and paternal history of criminal conviction for violent offences, and maternal and paternal history of a psychiatric disorder
Model 3- model 2 further adjusted for the presence of co-morbidity with ADHD or conduct disorder in the proband

Supplementary Table S2. Relative risk (95% confidence intervals) of violent criminality in individuals with autism by the presence of ADHD or Conduct disorder. **The autism diagnosis was recorded before the criminal conviction.**

Autism according to comorbidity			
All autism spectrum disorders	**ADHD/conduct disorder**	Model 1 RR (95% CI)	Model 2 RR (95% CI)
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.36 (5.04-5.71)	3.86 (3.61-4.12)
Present	Not present	0.97 (0.79-1.18)	0.91 (0.75-1.11)
Present	Present	2.09 (1.69-2.58)	1.82 (1.47-2.24)
Autism without intellectual disability	**ADHD/conduct disorder**		
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.36 (5.04-5.71)	3.86 (3.62-4.13)
Present	Not present	1.15 (0.92-1.43)	1.12 (0.89-1.40)
Present	Present	2.03 (1.58-2.62)	1.81 (1.41-2.33)
Autism with intellectual disability	**ADHD/conduct disorder**		
Not present	Not present	1.00 (Reference)	1.00 (Reference)
Not present	Present	5.37 (5.05-5.72)	3.88 (3.63-5.15)
Present	Not present	0.52 (0.38-0.92)	0.52 (0.33-0.81)
Present	Present	2.23 (1.51-3.30)	1.83 (1.25-2.68)

Modified Poisson regression models with cluster robust standard errors (cluster=birth mother)
Model 1: adjusted for age and sex
Model 2: model 1 further adjusted for maternal and paternal age, parental education at birth, household disposable income, migration status, maternal and paternal conviction for violent crime, maternal and paternal history of a psychiatric disorder

Supplementary Table S3. Relative risks of violent criminality among individuals with autism (n=5,668) in relation to family characteristics, psychiatric comorbidities, school grades and age at ASD diagnosis. **The autism diagnosis was recorded before the criminal conviction.**

	Model 1 RR (95% CI)	Model 2 RR (95% CI)
Male sex	1.97 (1.35-2.86)	1.91 (1.31-2.79)
Maternal age	0.93 (0.91-0.96)	0.96 (0.92-1.00)
Paternal age	0.96 (0.93-0.98)	0.99 (0.96-1.02)
Low education parents	1.58 (1.12-2.23)	0.99 (0.68-1.45)
Lowest income	1.73 (1.23-2.43)	1.40 (0.97-2.02)
Parent or child born abroad	1.51 (1.11-2.05)	1.38 (0.99-1.91)
Mother convicted of violent crime	2.33 (1.07-5.06)	1.51 (0.68-3.72)
Father convicted of violent crime	2.88 (2.03-4.09)	2.14 (1.47-3.12)
Mother has psychiatric history	1.47 (1.09-1.99)	1.21 (0.88-1.67)
Father has psychiatric history	1.36 (0.99-1.88)	1.08 (0.77-1.52)
ADHD or Conduct disorder	2.24 (1.66-3.02)	2.08 (1.53-2.83)
ADHD	1.86 (1.37-2.52)	1.71 (1.25-2.32)
Conduct disorder	5.15 (3.37-7.89)	4.68 (2.99-7.31)
Psychotic disorder	2.14 (1.29-3.53)	1.78 (1.06-3.01)
Drug and alcohol misuse	6.80 (4.80-9.63)	5.35 (3.69-7.77)
Personality disorder	1.61 (0.74-3.51)	1.45 (0.65-3.23)
Intellectual disability	0.64 (0.42-0.99)	0.55 (0.35-0.85)
Better than average school grades	0.55 (0.33-0.94)	0.70 (0.41-1.20)
Age of autism diagnosis (years)	1.01 (0.98-1.03)	0.99 (0.97-1.02)

Modified Poisson regression models, cluster robust standard errors (cluster=birth mother)
The adjusted model included all family characteristics, age and sex of proband and the presence of ADHD or conduct disorder.
Note: School grades available for 3341 individuals with ASD